

NASA Engineering Safety Center

NASA Aerospace Flight Battery Systems Working Group

2007 Proactive Task Status

Michelle Manzo

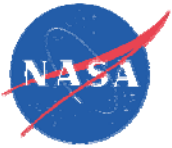
NASA Glenn Research Center

In 2007, the NASA Engineering Safety Center chartered the NASA Aerospace Flight Battery Systems Working Group to bring forth and address critical battery-related performance/manufacturing issues for NASA and the aerospace community. A suite of tasks identifying and addressing issues related to Ni-H₂ and Li-ion battery chemistries was submitted and selected for implementation.

The current NESC funded are:

- Wet Life of Ni-H₂ Batteries
- Binding Procurement
- NASA Lithium-Ion Battery Guidelines
 - Li-Ion Performance Assessment
 - Li-Ion Guidelines Document
 - Assessment of Applicability of Pouch Cells for Aerospace Missions
 - High Voltage Risk Assessment
 - Safe Charge Rates for Li-Ion Cells
- Availability of Source Material for Li-Ion Cells
- NASA Aerospace Battery Workshop

This presentation provides a brief overview of the tasks in the 2007 plan and serves as an introduction to more detailed discussions on each of the specific tasks.



NASA Engineering Safety Center NASA Aerospace Flight Battery Systems Working Group 2007 Proactive Task Status

NASA Aerospace Battery Workshop

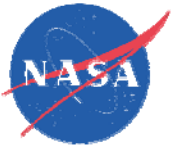
Focused Session

November 27, 2007



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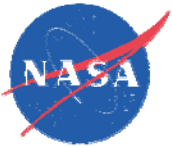


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Background:

- Summer 2006 – NASA Engineering Safety Center (NESC) call for proposals for proactive work addressing critical, high risk issues for the agency
- Battery Steering Committee – Identified and developed a suite of tasks designed to address current issues, submitted proposal to NESC
- Fall 2007 – Battery proposal selected
- January 2007 – Implementation plan presented to NESC board
 - Battery Steering Committee chartered as NASA Battery Working Group
 - Addresses critical battery-related performance / manufacturing issues for NASA and the aerospace community
 - NESC will entertain annual proposals for proactive tasks



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Objectives:

- Develop/maintain/provide tools for the validation of aerospace battery technologies
- Accelerate technology readiness and provide infusion paths for emerging technologies
 - Enable implementation of critical risk-mitigating test programs
- Disseminate validation/assessment tools, quality assurance and information to the NASA and aerospace battery communities
- Provide problem resolution expertise and capabilities

Scope: Support validation and verification of aerospace battery systems for NASA missions.

- Enable implementation and execution of critical test programs to reduce risk by addressing wide-ranging technology issues.
- Address issues affect the safety and success of future NASA missions

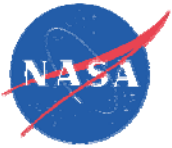


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Current Tasks

- **Wet Life of Ni-H₂ Batteries – GSFC**
 - Develop understanding of the effects of stand time on life and performance of Ni-H₂ batteries
 - Develop strategies for effective storage and impact of long-term storage on performance and life
- **Binding Procurements – GSFC**
 - Develop guidelines related to requirements for the battery system to be considered at the time of power system contract award



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Lithium-ion Safety, Handling and Qualification Guidelines

- **Approach**
 - **Performance Assessment**
 - **Guidelines Document**
 - **Focused Technology Tasks**
 - Assessment of Applicability of Pouch Cells for Aerospace Missions – JSC/JPL
 - High Voltage Risk Assessment – JSC
 - Procedure for Determination of Safe Charge Rates – JPL

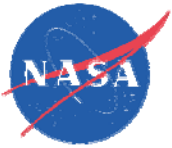


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Lithium-ion Safety, Handling and Qualification Guidelines

- Lithium-ion Performance Assessment – GRC
 - Survey of existing Li-Ion battery manufacturers (both within and outside of the United States) and their capability to meet future NASA mission needs.
 - Address multiple NASA mission needs: LEO, GEO, Constellation requirements and the use of commercial-off-the-shelf technology for portable applications.
 - Approach
 - Travel to manufacturers
 - Literature and internet searches
 - NASA developed survey
 - Phone inquiries



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- Li-ion Performance Survey – Nicole Smith, GRC, Paul Schmitz, PCS/GRC
 - The survey will describe the cells/batteries performance and the testing they have undergone (either at the manufacturer or by other government agencies) to help the mission planner/hardware developer in the battery/cell selection
- Implementation Method:
 - Develop a database (currently MS Excel) which contains information about Lithium-Ion cells and batteries which have either flown in space or are appropriate for space use (cells > 1 A-hr Capacity)
- Participants include both Govt. and Industry

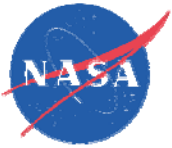


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Li-ion Performance Survey - Sample Data

Cell Manufacturer	Cell Type (Prismatic, Cylindrical, other)
Location of Owner / Facility	Specific Energy (Wh/kg) (define rated conditions)
POC/Name, contact information	Energy Density (Wh/l) (define rated conditions)
Cell Product Line	Specific Power (w/kg) (define rated conditions)
Cell P/N	Columbic Efficiency
Cell Chemistry/Components	Fade Rate
Cathode/Anode Composition	Charge Rate (A) (recommended?)
Electrolyte	Discharge Rate (capability?)
Cell Voltage (V)	Cell Steady State (A)
Cell Capacity (AHr) (at what rate?)	Cell Pulse (A)
Nameplate	Max (A)
Actual	Operating Temperature Range
Cell Mass (g)	Charge (°C)
Cell Dimensions	Discharge (°C)
Cell Width or Diameter (mm)	
Cell Height (mm) w/ and w/o terminals	
Cell Thickness (mm)	

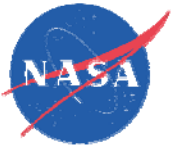


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Li-ion Performance Survey - Current Participants

- Naval Research Lab
- NASA Johnson Space Center
- NASA Glenn Space Center
- NASA Ames
- Lockheed Martin
- Quallion
- Saft
- Yardney
- Sanyo



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Li-ion Performance Survey – Future Work

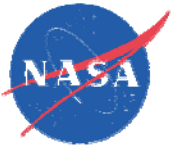
- Make database accessible via the web for
 - Access of information of battery/cells in database
 - Input of new battery/cell data via Web



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- **Lithium-ion Safety, Handling and Qualification**
- Li-ion Guidelines Document – GRC
 - Formulate generic qualification guidelines and recommendations for Li-Ion batteries for manned space flight applications.
 - Develop standardized approaches to defining, determining, addressing safety, handling and qualification
 - Address the risks associated with flying this new technology must also be ensured.



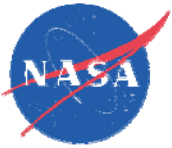
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Lithium-ion Safety, Handling and Qualification

Focused tasks - risk assessments

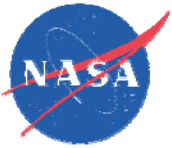
- Assessment of Applicability of Pouch Cells for Aerospace Missions – JSC/JPL
 - focus on corrosion, thermal excursions and long-term performance issues. Document defining requirements to maintain performance and life
- High Voltage Risk Assessment – JSC
 - focus on safety and abuse tolerance of battery module assemblies. Recommendations of features required for safe implementation
- Procedure for Determination of Safe Charge Rates – JPL
 - evaluation of various cell chemistries and recommendation of safe operating regimes for specific cell designs



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- **Lithium-ion Battery Source Material Availability –**
 - Provide additional support for the governmental Title 3 effort aimed at ensuring a constant supply of source material
- **NASA Aerospace Battery Workshop –**
 - Government-industry forum focused on battery industry developments and issues (held annually in the Fall)



NASA Aerospace Flight Battery Systems Working Group



Working Group Participants

NASA Glenn Research Center (GRC)

NASA Goddard Space Flight Center (GSFC)

NASA Johnson Space Center (JSC)

NASA Kennedy Space Center (KSC)

NASA Langley Research Center (LaRC)

NASA Marshall Space Flight Center (MSFC)

Jet Propulsion Laboratory (JPL)

Air Force Research Laboratory (AFRL)

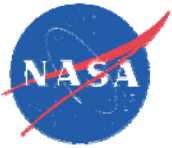
Aerospace Corporation

Naval Surface Warfare Center (NSWC)

Naval Research Laboratory (NRL)

Central Intelligence Agency (CIA)

National Reconnaissance Office (NRO)



NASA Aerospace Flight Battery Systems Working Group - NESC Tasks 2007 Battery Workshop Focused Session



- **Wet Life of Ni-H₂ Batteries** Gopal M. Rao, NASA GSFC
- **Binding Procurement** Hari Vaidyanathan, COMSAT - Lockheed Martin Technical Operations; and Gopal M. Rao, NASA GSFC
- **NASA Lithium-Ion Battery Guidelines** Barbara McKissock, Patricia Loyselle, Michelle Manzo, and Elisa Vogel, NASA GRC
- **Assessment of Applicability of Pouch Cells for Aerospace Missions – JSC/JPL**
 - **Lithium-Ion Cell Pouch Corrosion Investigation** John Weintritt, NASA / ESCG (JSC)
 - **Operational Requirements for Applications of Pouch Cells** Kumar Bugga, NASA JPL
- **High Voltage Risk Assessment – JSC**
 - **PTC Withstanding Voltage Thresholds in COTS 18650 Cells** Brad Strangways, Symmetry Resources, Inc.; Frank Davies, Judy Jeevarajan, and Eric Darcy, NASA JSC
 - **Limitations of Internal Protective Devices in Cylindrical Li-Ion Cells** Pranav Patel, G. Varela, F. Davies, E. Darcy, and J. Jeevarajan, NASA JSC
- **Safe Charge Rates for Li-Ion Cells** Kumar Bugga, JPL